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Manpower and Personnel Integration (MANPRINT): Some Preliminary Observations and Lessons Learned

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This report offers preliminary observations and lessons learned as a result of direct participation in and work accomplished under the MANPRINT program. The report provides a historical perspective on the continuing evolution of the MANPRINT program and outlines some considerations for improving the program.

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MANPOWER AND PERSONNEL INTEGRATION (MANPRINT):   SOME PRELIMINARY OBSERVATIONS
AND LESSONS LEARNED

CONTENTS

MANPOWER AND PERSONNEL INTEGRATION (MANPRINT): SOME PRELIMINARY OBSERVATIONS AND LESSONS LEARNED

Introduction

Purpose

Manpower and Personnel Integration (MANPRINT) is a comprehensive management and technical program to improve total system (soldier and equipment) performance through the continuous integration of manpower, personnel, training (MPT), human factors engineering, system safety, and health hazards considerations throughout the materiel development and acquisition process. The overall goal of the program is to design equipment that is compatible with the soldiers who will operate and maintain it.

Since its inception, MANPRINT has led to increased visibility for soldier issues early in the acquisition process. It has significantly upgraded and strengthened requirements for human performance considerations in procurement documents. It also has resulted in the development and application of new methodologies to improve system performance and estimation of human resources associated with new systems.

The purpose of this report is to offer some preliminary **observations and lessons learned as a result of work accomplished under** the MANPRINT program. This paper provides historical perspective on the continuing evolution of the program and outlines some considerations that may be used to improve the program. Observations and lessons learned offered here are deemed as preliminary since they were not derived through a formal research program but rather are based on informal observations and direct participation in the MANPRINT program.

Background

The MANPRINT program was developed in response to several continuing trends. These trends include an increasing reliance within the Army on high technology weapon systems, a shrinking pool of qualified military-aged personnel, and increasing concern for costs associated with supporting poorly designed or ill-conceived weapon systems.

Increasing reliance on high technology. Traditionally, the Army force modernization program has emphasized quality over quantity. This emphasis stems from the need to counter a numerically superior adversary. It also stems from the understanding that sophisticated systems can produce better results while requiring fewer skills and abilities from operators. For example, according to Cushman (1987), a 1986 Congressional Budget Office report lauds the M-1 Abrams tank as

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demonstrating the potential of high technology for improving performance. The report notes that M-1 tank crews' live-fire performance is 40 percent better and imposes fewer mental demands than the performance of crews firing the older, M-60 series tank.

Of course, ease of operation is not assured through advanced technology, nor is it the only issue. In fact, high technology has countervailing effects on overall system performance. Advanced technology systems do not necessarily reduce the operator's work requirements. They change them. They can help the operator perform better at tasks, do more tasks, or do more difficult tasks. However, the risk of overloading the operator, physically or cognitively, is at least as high with advanced systems as it is without them.

Numerous examples of systems designed without adequate attention to the problem of operator overload are provided by Cordes (1985). Perhaps the best example is the single crew member (pilot) F-18 fighter jet which reportedly has been dubbed the "porcupine" because of all the switches sticking from the throttle (nine switches, most of which have more than one function) and right-hand stick grip (seven additional switches). Added to these components are 59 indicator lights, 73 messages, 40 display formats, 675 acronyms, 177 symbols, and six warning tones that a pilot must react to quickly and correctly when they appear.

Diagnostics and in-house repairs on advanced systems also can impose more unique demands and require more specialized talent than those required on less sophisticated systems. To revisit the illustration of the M-1 Abrams tank, the tank may be easy to operate, but the technical manuals required to support it are almost three times larger than those required by the older, M-60 (Cushman, 1987).

Shrinking pool of qualified personnel. As the demand for the advanced operational capabilities of high technology systems grows, so too does the demand for human resources. The Army has labeled this phenomenon "skill creep." In general, more sophisticated systems require more capable and better trained operators and maintainers. Yet, the absolute size of the American work force is declining. Between 1980 and the mid-1990s, the Department of Defense (DoD) is faced with a 22 percent reduction in the size of its primary recruiting pool (18-24 year old males). There also are serious questions about the quality or capability of this smaller pool. DoD estimates that the median reading grade level of persons between 18 to 23 years of age is 9.6. As low as it is, this reading grade level is two to three grade levels higher than those of some minority groups. This situation is particularly troublesome considering that minority representation in the primary recruiting pool will grow from 20 to 30 percent by the year 2000 (Weddle, 1984).

Equally disturbing is testimony received by The National Commission on Excellence in Education (1983). The following excerpts were drawn from this testimony:

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- The College Board's Scholastic Aptitude Tests (SAT) demonstrated a virtually unbroken decline from 1963 to 1980. Average verbal scores fell over 50 points and average mathematics scores dropped nearly 40 points.

- College Board achievement tests reveal consistent declines in such subjects as physics and English.

- There was a steady decline in science achievement scores of U.S. 17-year-olds as measured by national assessments of science in 1969, 1973, and 1977.

- Between 1975 and 1980, remedial mathematics courses in public 4-year colleges increased by 72 percent and now constitute one-quarter of all mathematics courses taught in those institutions.

According to the Commission report, the Department of the Navy indicated that one-quarter of its recent recruits cannot read at the ninth grade level. This is the minimum reading grade level needed simply to understand written safety instructions. Obviously, with fewer and less qualified people available, recruiting sufficiently bright, military-aged personnel to meet the Army's requirements will become increasingly difficult.

Increasing concern for support costs. Coincidentally, concern arose over the long-term costs of supporting systems that do not take soldier requirements into account. For example, DoD estimated that the cost of redesigning a system is at least twice the cost of designing it originally (e.g., Malone, Kirkpatrick, & Kopp, 1986). Other DoD sources have estimated that the costs of manning, training, and supporting systems personnel account for over 50 percent of the total life cycle cost of a large-scale system (e.g., Malone, Heasly, Waldeisen, & Hayes, 1986). In times of inflation and budgetary constraint, an obvious means for cutting back costs is by looking for ways to reduce manning level requirements.

The cost of redesigning a system probably is trivial compared to the long-term costs associated with supporting a fielded system that is not designed to accommodate the personnel that are available to operate and maintain it. Such systems consistently waste limited human resources and yield poor operational performance. This point has been made repeatedly in well-publicized attacks on systems, such as the Division Air Defense gun (DIVAD), Dragon, and Stinger (e.g., Nelson, Schmitz, & Promisel, 1984). Furthermore, it has been driven home in recent studies that attribute over 50 percent of all military system failures to human error (e.g., Malone, Heasly, Waldeisen, & Hayes, 1986).

The Army's response: MANPRINT. By the early 1980s, it was clear that the demand for more and better operators and maintainers was far outstripping supplies. Equally important, efforts aimed at limiting human resources early during the materiel acquisition decision process

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showed signs of significant cost savings over the lifetime of the system. In response, the Army initiated the MANPRINT program. Army Regulation (AR) 602-2, the official MANPRINT regulation, was published approximately three years later in April 1987 (Department of the Army, 1987). Recent initiatives from the Department of Defense (Dir. No. 5000.53) (Department of Defense, 1988) and Congress (Title 10, U.S. Code) underscore the importance of the issues addressed by the MANPRINT program.

Preliminary Observations and Lessons Learned

Some preliminary observations and lessons learned are presented in the following sections along with some proposals for improving the MANPRINT program.

There are opportunities for MANPRINT to impact system design decisions in each phase of the materiel acquisition decision process, but it has been the earliest phases that have received the greatest attention. For this reason, the majority of the suggested lessons relate primarily to activities occurring during preconcept.

Preconcept Activities

A number of lessons learned came out of research on the M901/M901A1 Improved TOW (tube-launched, optically tracked, wire-guided missile) Vehicle (ITV) (Schendel, 1990). This research was experimental in nature but included a partial ECA on ITV operator tasks. Some of the most important lessons of this research pertained to the MANPRINT analytic process itself.

Recognizing the interdependence of MANPRINT domains. ECA and HARDMAN comparability analyses are MPT analyses. Neither deals specifically with human factors engineering, system safety, or health hazard issues. This shortfall is not peculiar to these analyses. No analysis that is not both technically oriented and labor intensive provides for the capture of these data on existing systems. Unless a special effort is made to capture these data, or unless information gathered in an ECA happens to suggest a particular problem, important lessons learned from the operators, maintainers, and repairers of to-be-replaced systems may not be transferred to the designers of the follow-on systems. At least no formal mechanism exists to assure that this transfer occurs. More fundamental is the issue of whether MPT domains can or should be separated from human factors engineering, system safety, and health hazards domains. MANPRINT domains are all highly interdependent. MPT and human factors engineering, especially, represent interdependent solutions to human performance problems. Different solutions may appear more or less sensible depending on the nature of the problem that is being addressed and the specific tradeoffs that must be made.

In addressing these issues, Schendel (1990) collected ECA task rating data and employed a three-step approach for assessing human factors engineering, system safety, and health hazards issues on the

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ITV. The approach entailed obtaining some firsthand experience with the system; obtaining copies of accident and test reports and analyzing them for critical human factors engineering, system safety, and health hazard issues; and obtaining feedback from current users and instructors as to the continuing relevance of the issues. The approach was successful in that it allowed for the identification of high driver tasks and brought a number of critical issues to light that were viewed as likely to impact the design of future combat vehicles.

Broadening analytic considerations. Both ECA and HARDMAN comparability analysis work to reduce predecessor system data to a limited set of quantitative terms. There is always the risk, under these conditions, that the results of these analyses will be credited with a degree of precision and completeness that is not possible in the absence of other, more qualitative observational data. Furthermore, the accuracy of predictions derived from these analyses depend on the correctness of underlying assumptions and the reliability of the data that are input. If the assumptions are wrong or the data are unreliable, conclusions derived from the analyses also may be wrong. For example, one assumption of the HARDMAN process is that the operator or maintainer who is performing each task has been adequately trained and is working without error. HARDMAN does not appraise the cognitive demands on the executor of tasks, and it is relatively insensitive to differences in human performance.

To overcome these problems, as suggested above, Schendel (1990) recommended obtaining some firsthand experience with the predecessor system (or systems); obtaining copies of accident and test reports related to the use of the system; and obtaining feedback from current users and instructors. Obtaining some firsthand experience with the predecessor system (or systems) is perhaps most useful. Without this experience, it is very difficult to ask the right questions in the right way, to interpret the answers, or to evaluate the significance of those answers for follow-on system designs. These recommendations are by no means new. Similar considerations have affected the design of earlier studies of the ITV (e.g., Hammond & Redden, 1984; Smith, Thompson, & Nicolini, 1980) as well as studies of other infantry weapon systems (e.g., Evans & Osborne, 1988).

Conducting "opportunity-oriented" analyses. Both ECA and HARDMAN comparability analysis focus on avoiding problems in future system designs. "Problem-oriented" analyses play an important role in the materiel development process. However, "opportunity-oriented" analyses also are needed.

Toward this end, Schendel (1990) recommended collecting: information about the best or most desirable design features of the predecessor system; information about the best or most desirable design features of systems related to the predecessor system; and ideas for improving the design of the follow-on system. This type of analysis was referred to as "Desired Features Analysis." Based on the

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quality of the input received, the analysis appeared to have merit.

Analyzing crew-level collective tasks. ECA focuses on individual soldier tasks. It does not treat crew-level collective tasks. The term "crew-level collective task" refers to a unit of work requiring more than one crew member for its completion.

In analyzing task data, Schendel (1990) reported evidence consistent with the idea that crew-level collective tasks should be considered in some type of front-end analysis. This analysis need not be ECA, although it could be. Crew-level collective tasks are potential candidates for high drivers, especially considering the numbers of personnel involved and the interactive nature of their performances. It is important to assure that all crew-level collective tasks are not systematically disregarded in analyses for new weapon systems simply because they are collective tasks.

Expanding the concept of comparability. Both ECA and HARDMAN analyses are based on the concept of "comparability." Certainly some systems provide better predecessor system models for judging resource requirements than other systems. However, it is important not to become too parochial in the regard for data derived from MANPRINT analyses on seemingly unrelated systems.

As an illustration, the ITV is distinctly different in many ways from its planned successor, the line-of-sight antitank (LOSAT) vehicle. Yet, by studying the ITV, valuable insights were gained in a host of areas for the design of LOSAT and other future combat vehicles. This suggests that it may be possible for MANPRINT analysts to open up new channels of information exchange simply by expanding current notions of the term "comparability." In the near term, this may be accomplished simply by expanding the exchange of information that occurs within and between services. In the long term, the use of a MANPRINT data base such as the one being instituted at the Army Materiel Readiness and Support Activity (MRSA) may be helpful. If successful, the long-term effect of this recommendation should be to facilitate the identification and implementation of "desired features" across systems while, at the same time, conserving valuable MANPRINT analytic resources.

Validating SME opinion data. ECA uses SME opinion as a primary source of predecessor system data. Obtaining opinions from SMEs has merit as long as these opinions are validated through other means, preferably through firsthand experience. Validation is seen as essential since what is "true" for one SME frequently is not "true" for another.

As an illustration, Schendel (1990) used different groups of soldiers as SMEs, including unit solders, instructors, and students, and reported clear differences in the way in which they rated tasks. These differences were attributed both to the amount of time an SME had spent using a system and his current job requirements. SMEs with

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5 to 7 years of experience rated far more tasks as problem tasks than SMEs with less experience. Similarly, SMEs who were serving as crew members in units identified different tasks as problem tasks and for different reasons than soldiers who were serving as instructors. These effects also held true for human factors engineering, system safety, and health hazards issues rated as "serious" problems.

Increasing emphasis on the system MANPRINT management plan. Other lessons learned related to activities during preconcept pertain mainly to SMMP development. First is the question of the goal in this development. From a MANPRINT perspective, the knowledge and the plan of action developed through the SMMP process is critically important. Yet there is always the risk that a requirement, like the SMMP, aimed at improving total system (soldier and equipment) performance, will not be perceived as a means to an end, but as an end in itself. When this occurs, reasons for preparing the SMMP change. The goal then becomes finding the simplest way to meet the requirement and complete the paperwork rather than influencing system development and acquisition.

There are few good ways, apart from providing necessary command emphasis, to assure that efforts directed toward the preparation of the SMMP are not solely for purposes of "meeting the requirement." In many ways, the meaningfulness of MANPRINT, like the meaningfulness of the SMMP process, depends directly on the top-down emphasis it receives.

A second lesson learned pertaining to SMMP development relates to the need to share information and to maintain the SMMP as a living document. This is particularly true given the current emphasis on streamlined acquisitions. As the development process for a specific system accelerates, so too does the need for information. Inevitably, disconnects occur. When working under compressed time schedules, the results are usually fairly predictable:

• Test data will not be available when needed.

• When they are available, the time when they may have had an impact will be passed.

• As a result, new concerns will develop, and there will never be enough time to address them.

Information sharing should help needs to be addressed as they arise. Maintaining the SMMP as a living document also should facilitate the management and tracking of critical issues across the life cycle of a system. In this way, these issues can be kept alive and capable of influencing subsequent system design decisions.

Another way to promote the overall MANPRINT process is to ensure that the SMMP is easily useable and contributes to system acquisition. As the one complete MANPRINT document, the SMMP should facilitate the crosswalk of MANPRINT information into system requirement, program

management, and solicitation documents. For example, the format of the SMMP could be modified to include specific MANPRINT information to be inserted in the O&O plan, ROC, RFP, and TEMP.

Concept Exploration and Definition Phase

An effective MANPRINT program depends on human performance considerations being integrated with hardware/software requirements. This can be accomplished only by embedding MANPRINT issues in system requirements documents.

There is one main point that should be made related to requirements documents, in particular, the ROC. Just as the SMMP development process is affected by compressed time schedules, so too is the ROC. As a result, MANPRINT frequently becomes a reduced priority on a long list of priorities. To assure that MANPRINT is assigned the priority it deserves in the ROC, it is especially important for leadership to solicit reviews from members of the MJWG and attend to their input.

A potentially useful product that could be developed during concept exploration is a tailored TAD. This TAD would incorporate the results from early MANPRINT analyses (e.g., ECA, HARDMAN) and be tailored specifically to the system being developed as opposed to the baseline MOS descriptions used initially. The tailored TAD could be used as a vehicle for forwarding specific observations related to soldier capability and performance to industry. It could become an attachment to the demonstration and validation solicitation document.

Concept Demonstration and Validation Phase

Improving the solicitation process. Assuring a suitable response from industry to solicitation documents is a multifaceted problem. Solicitation documents should reflect the MANPRINT constraints developed up to that time. MANPRINT also should be included in the source selection evaluation as a critical factor in determining prospective industry developers. To a large extent, the emphasis that the government places on MANPRINT guides industry's approach to integrating MANPRINT in the design and development process.

Related to the need for government to include MANPRINT in source selection evaluations is the need for government to tie contractual Statement of Work (SOW) requirements to specific deliverables, either Contract Data Requirements List (CDRL) or hardware. One reason for this recommendation is to help assure that private industry treats MANPRINT requirements seriously. Another reason is that industry frequently depends on CDRLs as a means of allocating resources, including justifying new hires. If there are no MANPRINT CDRLS, it is very difficult for industry to justify an investment of constrained resources in MANPRINT.

Expanding the government-industry dialogue. Equally important is the need for government to improve its communications with industry.

The government frequently places the information gathering burden on prospective bidders at a time when industry-government interactions are restricted and industry may be incapable of collecting this information on its own. Information which is especially needed and virtually impossible for industry to obtain includes operationally defined (measurable) MANPRINT goals and requirements, TADs, descriptions of specific tasks to be trained, and pertinent information on comparable or predecessor systems. Along these same lines, the SMMP absolutely should be provided to industry as Government Furnished Information (GFI) within the Request for Proposal (RFP) package. These same recommendations were made by the Joint Army/Industry MANPRINT Working Group (1989), Project Manager for Training Devices (PM TRADE), Orlando, Florida. The Working Group included representatives of industry, academia, and government.

Full Scale Development Phase

The principal MANPRINT objectives during this phase are: to determine if MANPRINT goals and constraints have been adequately addressed, to identify and resolve any outstanding human performance issues, and to provide for the fielding of the system.

As indicated earlier, IOT&E provides a unique opportunity to determine if a system was designed to meet critical MANPRINT performance requirements. IOT&E represents the first time in the development of a system that soldier performance is tested at the task level under realistic, operational conditions. IOT&E also provides an excellent opportunity to collect the information needed to assess the success of a system MANPRINT program. MANPRINT programs, like key MANPRINT issues, need to be assessed. Information derived from this process can serve both informational and motivational functions and is essential for growth.

Production and Initial Deployment Phase

As suggested earlier, MANPRINT receives its greatest emphasis during the early stages of a system's development. In one sense, this emphasis is not inappropriate. It is during the early stages of a system's development that MANPRINT can have the greatest impact on the design of the system in question. In another sense, this emphasis can lead to the consideration of system specific problems in very short-sighted ways. For example, insights into system design problems that "come too late" to affect the design of a specific system may be regarded as "wasted" or inappropriate. They may be regarded as disruptive attempts "to derail a fast-moving train" when, in fact, they represent honest efforts to present cost-effective solutions to perennial design problems.

To be effective, MANPRINT must be regarded as an iterative process. It must be seen as depending on the accumulation of observations and lessons learned over the life cycle of specific systems. This is the only way that future systems can be adapted with

any degree of efficiency to satisfy soldier performance requirements. Once a system is deployed, experiences in Army training centers and units and under simulated combat conditions, like those at the National Training Center (NTC), are vital to achieving a clear understanding of the problems affecting a system so they can be avoided in future systems. So too are data obtained in private and public research settings. This suggests the need to collect MANPRINT observations and lessons learned related to the use of specific systems. Preferably, these observations and lessons learned would be collected as they become available so that they may be shared with others involved in the development of "comparable" systems. Today, there are any number of ways that these observations and lessons learned can be collected, stored, and rapidly disseminated. The key is to assure that this information is made available and is easily assimilated by those who need it when they need it.

Summary and Conclusions

The purpose of this report was to offer some preliminary observations and lessons learned as a result of work accomplished under the MANPRINT program. The word "preliminary" has been used here since the observations and lessons learned were not derived through a formal research program, but rather were suggested by informal observations and direct participation in the MANPRINT program. The report provided historical perspective on the continuing evolution of the MANPRINT program and outlined some considerations for improving the program.

Based on results of this preliminary review, it may be worthwhile to conduct a more formal assessment of the MANPRINT program. The intent of this review would be to look for new ways to strengthen the program. Especially needed are means for increasing the exchange of information between MANPRINT participants, both within government and between government and industry. Also needed are means for assuring that new data, issues, concerns, and proposed solutions developed during the course of a system's life cycle are properly tracked. As indicated, MANPRINT is an ongoing, iterative process. Conserving resources when working through such a process depends directly on effective information networking and management.

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